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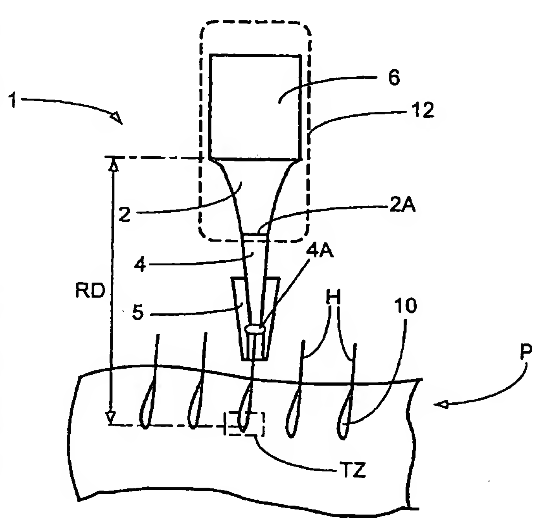
(54) Title: A METHOD AND DEVICE FOR AFFECTING AN OBJECT BY ACCOUSTIC RADIATION



(57) Abstract: The present invention concerns a device for affecting a body part, such as hair (4), tumor which is to be treated, destroyed or removed. The device comprises a transducer (6) and resonator which produce resonating waves causing said treatment destruction or removal.

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A METHOD AND DEVICE FOR AFFECTING AN OBJECT BY ACOUSTIC RADIATION

FIELD OF THE INVENTION

The present invention is generally in the field of acoustic radiation based treatment, and relates to a method and device for affecting an object by acoustic radiation. The invention is particularly useful for treating objects such as hairs, teeth or tissue parts.

BACKGROUND OF THE INVENTION

Techniques aimed at treating an object affixed to tissue so as to affect it while in the tissue are widely used for cosmetic or surgical purposes. One of the most common problems in techniques of the kind specified is treating the hair root or follicle as part of the hair removal process. Various methods and devices have been developed for temporary or permanent removal of undesired hair.

Some of these methods utilize a hair cutting technique, for example shaving. Unfortunately, this technique affects only that part of the hair shaft, which is located outside the skin, while the living part of the hair (in the hair follicle attached to papillae) continues to grow. Hence, the hair removal effect is short lasting.

Another method is based on plucking the hair out of its follicle, either by suitable mechanical devices or by the use of sticky substances, such as wax. Waxing, whilst taking out most of the hair adhered to wax and tearing apart the hair or disconnecting it from its follicle and papillae, leaves the papillae itself at least partially vital. Consequently, the living cells will establish a new hair germination zone, subsequently leading to renewed hair growth. Waxing can leave hair papillae and skin pores sore and open to infection, and cannot be used in cases of varicose veins, moles or warts.

Yet another method utilizes the chemical dissolving of hair using chemicals suitable for depilation. Such depilation by chemical agents is carried out by using gels or creams that contain highly concentrated alkaline chemicals, usually calcium thioglycolate, that dissolve the protein structure of the hair, leading to it its separation from the papillae. The concentration of the chemical is kept as low as possible so as to allow hair lysis, while avoiding skin irritation. The effect of depilation by chemical substances is also relatively short-term, and is occasionally accompanied by skin irritation.

Some of the known methods aimed at the permanent destruction of hair roots utilize electrical currents (electrolysis) or laser beams. Electrolysis is performed by transmitting a direct current to the hair root in order to form hydroxyl ions that electrochemically destroy the germinative cells of the hair follicles. Electrolysis can also be performed using high frequency currents to heat the water of the hair follicle and electrocoagulate the germinative hair cells. Although electrolysis is considered as a permanent method for hair removal, there is still a re-growth of 15-50% of the removed hair after treatment. Moreover, these methods utilize the insertion of a needle into the hair follicle, which is a rather painful and infection-prone process. The results of this procedure are heavily dependent on the skill of the person operating the electrolysis-based devices, and unskilled treatment may cause pigmentation, scarring of the skin, infection and small electrical shocks.

Another technique for the permanent destruction of hair roots utilizes laser radiation, and is disclosed, for example, in U.S. Patents Nos. 5,632,741 and 5,752,948. According to this approach, a focused laser beam is transmitted to the hair follicle, and optionally, a previous application of black colored solution is used to increase the energy absorption. The hair, or the dark solution, absorbs the laser energy, and as a result, its temperature increases leading to the destruction of the follicle. However, this technique depends on individual hair color and achieves acceptable results mostly in cases where there is a combination of dark hair and light skin. Persons having dark skin or light hair are not ideal candidates

for hair removal by laser radiation. Even optimal candidates suffer from 40-80% hair regrowth after 12 weeks, and have further side effects such as irritation (redness), change of the skin pigmentation and even scarring.

U.S. Patent No. 4,566,454 discloses the application of radio frequency (RF) waves to a hair at a selected frequency, at which the hair impedance to RF energy conduction is substantially lower than at other RF frequencies. Generally speaking, the main principles of this technique consist of finding and selecting an RF resonant frequency for a given hair to reduce the hair impedance to RF energy, since the resonant frequency varies from hair to hair. According to this technique, the hair shaft is engaged by tweezers as close as possible to the skin level, thereby enabling to reduce the resistance-contribution of that part of the hair shaft which is located above the skin, as compared to that of the other part located below the skin.

A technique, later developed by the same author, is disclosed in U.S. Patent No. 5,470,332, and consists of a pre-treatment of the hair prior to applying electromagnetic energy thereto. This pre-treatment makes the hair more receptive to the electromagnetic energy prior to its reaching the root of the hair. A recently developed technique (U.S. Patent No. 5,846,252) is based on the use of electromagnetic energy (AC, DC, DC-based RF and laser energy), and, optionally, the pre-treatment of the hair.

SUMMARY OF THE INVENTION

There is accordingly a need in the art to facilitate the desirable affecting of an object or tissue by applied energy, by providing a novel method and device utilizing acoustic radiation.

It is a major feature of the present invention to provide such a technique that enables to affect, either invasively or non-invasively, tissues or objects at least partly located inside a body.

The present invention takes advantage of the fact that most objects (e.g. hair), whilst being poor conductors of electricity and of light energy, are relatively

good conductors of acoustic waves. To cause oscillations of compartments of tissue, organ or an object affixed to tissue, so as to affect any of the tissue or object component or break the connection between them, acoustic waves can be applied to the tissue or the affixed object.

According to the present invention, a resonance condition of the acoustic waves is provided within a treatment zone located in a resonance plane. A predetermined location to be treated, which may be located inside or outside the object, should be in a resonance plane, namely in the plane where the resonance condition is satisfied. The object that contains this location or leads to this location (i.e., transmits the acoustic radiation thereto) could itself serve as part of a resonator. This enables to create the desired effect and to shorten the time required for obtaining the effect, and allows for a significant reduction of the amount of energy required.

The term *"object"* used herein signifies any tissue, organ or any other living creature part, which is at least partly located inside an individual's body, and mostly contains an unwanted object/substance, e.g., hair, tumor, etc., which is to be treated, destroyed or removed. The location to be treated by the acoustic radiation may the tooth root, which can be affected without the need of drilling it. Such a location to be treated may be the bone's junction or bone's fracture (in which case the release of calcification or treatment of bone-joints should be carried out), weak points, such as heart valve that can be treated without any surgical treatment of the heart itself, etc. Generally speaking, the treatment of a predetermined location may be performed via the same object containing this location, or via another object, tissue or living creature.

To remove the object from the tissue, the application of acoustic waves, that might be standing waves, may be amplified by cavitation and/or heating effects, caused by the same waves or by other transmitted waves, to improve, enhance or augment the effect.

There is thus provided according to one aspect of the present invention, a device for affecting an object affixed to tissue, the device comprising a transducer

actuated by a power source for generating acoustic waves and a resonator transmitting said acoustic waves and producing resonating waves that cause a desired effect within a treatment zone located substantially at a predetermined location relative to the object.

The desired effect to be achieved at the predetermined location may be a resonance condition or a strain condition. This predetermined location may be either inside or outside the object to be affected. For example, when dealing with hair removal, such an object is the hair root. The case may be such that the object to be affected is the patient's bone formed with a tumor- or infection-containing region, which may be located either inside the bone or in the closest vicinity to the bone.

The resonator comprises an acoustic waveguide element in the form of a hollow horn filled with a medium having required (sufficiently good) acoustic-wave transmission properties. The distal end of the horn is coupled to the object to be treated, for example though a tip-like element. The acoustic waveguide element could also be a single compact unit made of any suitable material.

The object to be affected by the acoustic radiation may be of a kind partly projecting out of the skin (e.g., a hair or a tooth). In this case, the distal end of the horn (or of the tip-like element, or of an element of any other type capable of transmitting acoustic waves, as the case may be) is directly coupled to an end of the object located outside the skin. The object to be affected by the acoustic radiation may serve as part of the resonator. In other words, the resonator may be formed by the horn (optionally provided with the tip-like element) and the object. The object to be affected may be entirely located inside the tissue. In this case, the distal end of the horn (or of the tip) is attached to a skin portion above the object. A leading (distal) edge of the device may also be adapted for penetrating into the body, if required by a specific application.

Preferably, the distal end of that part of the resonator, which is in contact with the object (directly, through the skin portion or invasively) is formed with a

beveled or sloped edge, so as to adjust the resonance condition to the predetermined location relative to the object. Alternatively or additionally, the operation of the transducer may be such as to transmit the acoustic waves with the frequency varying according to a predetermined frequency pattern within a preset frequency range.

Each of the above designs (geometrical/constructional or operational, respectively) actually presents a scanning technique, which is preferred when the object to be affected serves as part of the entire resonator, and when the height of the object is not known exactly. Such a situation may occur when applying the resonance condition to follicle (root) through its hair shaft, while the depth of the hair root location cannot be accurately predicted. As a result of such scanning, the resonance condition occurs at a certain location (point or plane), either within the area defined by the surface area of the beveled or sloped edge, or within the frequency range of the transducer, corresponding to the resonator length or operating frequency, respectively, of the resonance condition. Only that object which leads to this point, and which together with the acoustic waveguide element satisfies the resonance condition, will be successfully affected.

In the case when the object to be affected is entirely located inside the skin, the device may also comprise a needle-like member that is coupled to the distal end of the horn (e.g., through the tip-like element), and is capable of penetrating the tissue by its opposite end.

According to another aspect of the present invention, there is provided a cosmetic method for the removal of hair, comprising the steps of:

(a) generating acoustic waves;

(b) transmitting the acoustic waves through a resonator and moving an acoustic waveguide element of the resonator to scan a hairs containing skin portion with transmitted acoustic waves, wherein said transmitted acoustic waves are resonating waves causing a desired effect within a treatment zone located substantially at a predetermined location relative to the hair.

Preferably, the transmission of the acoustic waves is performed in such a manner that the frequency of the acoustic signal varies according to a predetermined frequency pattern within a preset frequency range.

The method may also comprise the steps of creating a heating effect and/or cavitation effect in the vicinity of the treatment zone. This heating effect is created either by resonance oscillations of the treatment zone, or by a suitable external means. Cavitation effect consists of rapid creation of gas bubbles in liquid due to acoustic radiation, pulsation of these bubbles and their final collapse. This phenomenon is caused by the rapid transfer from super-pressure to sub-pressure, which the acoustic force produces on the bubbles.

BRIEF DESCRIPTION OF THE DRAWINGS:

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates a device according to one embodiment of the invention intended for hair removal;

Fig. 2 more specifically illustrates the hair growth within the tissue;

Fig. 3 illustrates a hair removal device according to another embodiment of the invention;

Fig. 4 illustrates a hair removal device according to another embodiment of the invention;

Figs. 5a and 5b illustrate two different examples, respectively, of the application of the device of either of Figs. 1 or 3 for affecting the patient's bone;

Fig. 6 illustrates a system utilizing the device of either of Figs. 1 or 3, more specifically illustrating additional features of the invention; and

Fig. 7 is a schematic illustration of a device according to the invention applied for invasive treatment of the distal and internal part of an organ via its proximal end.

DETAILED DESCRIPTION OF THE INVENTION:

Referring to Fig. 1, there is illustrated a device, generally designated **1**, constructed according to one embodiment of the invention. The device **1** is exemplified as being intended for removing hair, generally at **H**, from an individual's body-part **P**, but the same device may be used for affecting component of or removing of a patient's tooth. The device **1** is in the form of a handheld instrument including an acoustic horn **2** and a tip-like element **4** coupled to a distal end **2A** of the horn **2** (constituting together an acoustic waveguide element). It should, however, be noted that the provision of the tip **4** is optional. The horn **2** and tip **4** may be composed of solid ultrasonic conducting material, for example titanium alloys, or alternatively one of them or both may be hollow, filled with a medium having good acoustic wave transmitting properties, for example water. Mounted at an upper end of the horn **2** is a transducer **6** coupled to a power source, which is not specifically shown.

The transducer **6** is of the kind capable of generating an acoustic response to electric signals supplied from the power source, and may, for example, be of a piezoelectric type. The construction and operation of such a transducer are known *per se*, and therefore need not be more specifically described except to note the following. For the purposes of the present invention, the transducer **6** generates acoustic signals, either in the ultrasonic range (i.e., more then 20kHz) or in the range of audio signals (i.e., less than 20kHz). The operation frequency of the transducer may be desirable altered, as will be described more specifically further below.

The tip **4** is capable of fastening the hair **H**. To this end, the butt-end of a distal end **4A** of the tip may be coated with a gluing material, such as wax. Alternatively, or additionally, although not specifically shown, any suitable mechanical gripping means may be used.

As further shown in Fig. 1, as a non-limiting example, an acoustically absorbing element **5** surrounds the distal end **4A** of the tip. In other words, only the central part of the distal end **4A** presents an "active" acoustic tip. By this (i.e., by

means of the spacer element **5**), a certain "safety" zone, or acoustic isolator, is provided in the vicinity of the hair captured by the tip. Only the hair attached to the central part of the tip will be influenced by the acoustic radiation, while tissue in the closest vicinity of the hair will not directly interact with the "active" acoustic tip. In the case that the tip-end **4** or compartment **4a** touches the skin, no leakage of energy into the skin will occur, due to the isolating spacer **5**.

In this specific example, the horn **2**, tip **4** and hair **H** form together an acoustic resonator, the horn and tip presenting the first acoustic waveguide element thereof, and the hair presenting the second acoustic waveguide element. Parameters of all the resonator parts are adjusted so as to enable the creation of a resonance condition, namely resonating waves, or strain, substantially at the location of a root portion **10** (constituting a predetermined location) of the hair **H**. In other words, the passage of the acoustic radiation through the entire resonator (horn, tip, hair shaft and hair root) creates the resonance condition at the root portion of the hair, which is located in a treatment zone **TZ** (shown as a dashed line in the figure) at a distance **RD** from the transducer **6**. For this purpose, a certain average hair height is considered.

As further shown in Fig. 1, the horn **2** and the transducer **6** are accommodated in a housing **12** (shown in dashed lines), made of a suitable acoustically insulating material for convenient holding of the instrument when in operation thereof. Although the tip **4** is shown in the figure as partly projecting from the housing, it is understood that it may be substantially entirely located thereinside, except for the end-portion thereof covered by the spacer **5**.

Geometrical parameters of the horn and tip should be calculated according to the material they are made of, its acoustic impedance and velocity of the sound propagation therein. As for the operating parameters, they may be within any suitable range starting from splits of Watts and splits of seconds of pulse duration.

Reference is now made to Fig. 2, more specifically illustrating the hair accommodation in the tissue. The hair **H** has its shaft portion **12A** and a root portion **12B**. The hair shaft **12A** recedes into the skin, past the *stratum*

corneum **14**, epidermis **16**, through the sebum partially-filled gap **18** within the follicle **20**, and ends in the epidermal invagination in dermal layer **22** at the hair root **12B**, which is covered by the follicle bulbous area **24**. The hair root **12B** is fed from nurturing capillaries **26** via the papilla. To enable hair removal, the hair root **12B** and the papilla **26**, or follicle **24**, needs to be destroyed. During treatment, the papilla **26** is located at the outlet of the resonator, within the treatment zone **TZ** (shown in dashed line), and should be affected by the resonating waves, or other, not necessarily resonating waves produced by the radiation propagation through the object/tissue and their effects created therein.

The energy of the resonating wave, produced via the interaction of a primary wave (coming from the hair shaft) with that reflected from the papilla causes sufficient mechanical distortion, vibration, bending and torsion-created torque, or thermal elevation, or cavitation, for the destruction of hair root follicles and/or papillae. These phenomena may be created, also at lower efficiency, also without being at the resonance plane. The procedure can be either carried out on untreated skin, or may include a pretreatment of hair by drying and trimming the hair. When utilizing the hair shaft as part of the resonator, the hair may be pretreated by various gels to make it more rigid. Hair serves best as a waveguide when it has certain tension, so that during treatment it can be pulled out straight, possessing some minimum tension.

The resonating of the root portion causes a heating effect that facilitates the hair root, follicle or papillae destruction and hair removal. Additionally, such a heating effect may also be created by suitable external means, to enhance the irradiation effects. Further effects might result from creation of other phenomena, for example causing a cavitation effect.

Fig. 3 illustrates a hair removal device **100** according to another embodiment of the invention. The device **100** is constructed generally similar to the above-described device **1** (Fig. 1), but has a somewhat different design of a tip-like element. To facilitate understanding, same reference numbers are used for identifying those components, which are identical in the devices **1** and **100**. Here, a

distal end **4A** of the tip **4** is formed with a beveled/sloped edge **104**. Hairs H_1, H_2 and H_3, whose root portions are differently aligned inside the tissue relative to the skin-plane (i.e., along the z-axis), are captured by the end **4A** at different points within the surface area of the beveled edge **104** having different locations along the z-axis.

The main idea of this configuration is based on the fact that different hairs practically have different heights or lengths, while the resonance condition defined *inter alia* by the length of the entire resonator (a so-called "resonating distance") composed of the horn, tip and hair shaft, corresponds to a specific predefined hair shaft length. This hair length is such that the entire resonator contains an integer number of half-wavelengths (at a given value of the operating frequency), and therefore the root portion of this specific hair coincides with the treatment zone. The provision of the beveled edge presents additional scanning of the skin portion along the z-axis within the surface area defined by that of the beveled edge, so as to affect those hairs whose lengths satisfy the resonance condition.

Thus, during the movement of the device along the *x*-axis parallel to the skin surface, the beveled edge **104** of the tip successively captures hair' ends differently aligned along **x**- and **z**-axes, enabling those hairs whose heights satisfy the resonance condition to be successfully affected. Additionally, although not specifically shown, at any current location of the tip relative to the skin, it may capture by its beveled edge an array of hairs, mostly at least one of them satisfying the resonance condition. As clearly seen in the figure, the root-portions of hairs H_1 and H_3 and their surrounding elements are located at different depths. However, owing to the fact that the upper ends of these hairs are coupled to different locations along the beveled edge **104**, they may be successfully affected, if the corresponding resonance distances are substantially equal. Namely, the resonance distance RD_1 formed by the entire length of the resonator associated with the hair H_3 is substantially equal to the resonance distance RD_2 formed by the entire length of the resonator associated with the hairH_1.

It is important to note that since the resonance condition is also defined by the operating frequency value, this value can be specifically varied (in accordance with a specific frequency pattern) within a predetermined frequency range. Similarly, this presents a scanning effect, such that during the operation of the device, the location of the treatment zone (where the resonance condition is created) sequentially varies in accordance with the sequential changes of the resonance condition parameter (frequency). At least one of these resonance condition parameters will fit the treatment zone at the root portion of the hair(s) captured by the tip to create this desired effect. This can be implemented, for example, by having a transducer or probe of wide frequency range that is activated concomitantly, or with short time intervals, with pulses of various frequencies.

It should be specifically noted that if the resonator does not utilize a tip-like element, and the distal end of the horn is to be directly coupled to the hair end, this distal end is preferably formed with the beveled edge.

Fig. 4 illustrates a hair removal device **200** according to yet another embodiment of the invention. Here, the resonator includes the horn **2** in the form of a hollow cylinder filled with water **202**, and a thin elastic membrane **30** located at the distal end **210** of the horn **2**. Here, in distinction to the previously described examples, the hair does not necessarily serve as part of the resonator. Resonating waves are generated by the transducer **6** and propagated through the acoustic waveguide horn, with the membrane **30**, thereby causing the resonance oscillations of the membrane **30**. Hairs H are adhered, for example by using a gluing material provided on the outer surface of the membrane facing the skin, and are stretched and relaxed with the membrane oscillations. The acoustic wave propagates through the hair shaft **12A**, and affects the hair root **12B** by pull and push movements that cause periodical stress. As loading is applied throughout many cycles, the root reaches a state of fatigue and detachment of the follicle-root zone, after which the hair is freely removed.

It should be noted that the provision of the membrane **30** in the configuration of Fig. 4, as well as the provision of the tip **4** in the configurations of

Figs. 1 and 3, is optional. The distal end of the horn **2** could be directly connected to the hair shaft via an aquatic solution or acoustic coupling gel.

It should be understood that a suitable calculation scheme is appropriately selected for defining the geometrical and operating parameters of the device. This scheme depends on that the hair shaft is or is not to be used as part of the resonator. All the above-described examples are suitable for non-invasively affecting other objects attached to tissue, for example a patient's teeth, provided the calculation scheme is appropriately selected. Generally speaking, the calculation scheme is defined *inter alia* by operating, geometrical parameters of the device, as well as materials used for constructional parts of the device and those of the object to be affected by the acoustic radiation.

Reference is now made to Figs. 5a and 5b illustrating another application of the present invention aimed at affecting the patient's bone by utilizing the bone, or bone parts, as part of a wave-guiding system (resonator). A device **300** is constructed generally similar to the above-described devices, and therefore only that constructional part thereof which is relevant for the description below is illustrated, namely the beveled or sloped edge **104** of the tip. As indicated above, the provision of the tip element is optional, and therefore this beveled edge may be associated with the distal end of the horn.

The ultrasonic horn **2** transmits acoustic oscillations that propagate into the sloped end **104** of the tip **4**. The tip's sloped end **104** serves as a working surface, which contacts an extremity **304** at a point **306**, presenting the closest location of a bone **302** relative to the body's surface. By choosing the appropriate acoustic frequency, the entire resonator (horn, tip and bone) a creates a resonance condition, the maximal oscillation, strain and, as a result, therapeutic effect, being achieved at the bone candela located in a treatment plane (zone) $\mathbf{TP_1}$ (Fig. 5a) at a corresponding resonance distance $\mathbf{RD_3}$ from the transducer surface. This zone $\mathbf{TP_1}$ may be a joint, infectious region, tumor etc.

Movement of the contact point along the slope **104** of the tip **4** may alter the resonance conditions, but will simultaneously shift the treatment plane $\mathbf{TP_1}$ from its

former place to a plane TP_2 located at distance RD_4 from the transducer surface (Fig. 5b) without changing the oscillation frequency. This zone TP_2 may be a tumor-containing bone region, or epiphysis, whose growth is to be stopped or at least slowed.

As mentioned above, the beveled edge based effect can be replaced or added by electro-optic or acoustic effect, e.g., alteration of the treatment plane can be performed also by altering the irradiation frequency.

Turning now to Fig. 6, there is illustrated a system, generally designated **400**, utilizing a resonance device according to the invention for the ultrasonic treatment of internal organs. The system comprises such main constructional parts as a signal generator **402**, an ultrasonic unit **409** (constituting the resonance device) and a control unit **430** with feedback circuit **440**.

The signal generator **402** contains a voltage source **404**, a frequency converter **406** and a signal amplifier **408**, which are all connected to a power supply **426**, and can be constructed as a single unit or else used as separate units. The signal generator **402** activates the ultrasonic transducer **412**, which sits in a transducer holder **410**. Via an acoustic propagation medium **414** containing an optional reflecting-monitoring surface **424**, the ultrasonic wave propagates through an ultrasonic horn **416**, which increases the density of the energy irradiated and directs it to tip **418** formed with a slope **420**. The provision of the acoustic mirror **414** is optional and is used, for example, when changes of the direction of the ultrasonic wave are needed. The slope **420** of the tip **418** changes the distance between the transducer **412** and a treatment plane located somewhere inside a body **422**, for example as described above with reference to Figs 5a and 5b.

The reflection monitoring surface **424**, acts as sensor that measures a back-scattering wave and transducer parameters, such as vibration frequency and amplitude, generates data indicative thereof, and transmits the data into the control unit **430** via a cable **405** (or wireless). The control unit comprises suitable hardware and is operated by suitable software for maintaining the ultrasonic unit performance at an optimal level. To this end, the control unit **430** may comprise an

emergency switch **432**, a timer **434**, a power meter **436**, which measures the actual transducer power and magnitude of the back-scattering wave, and a main processing unit **438**. The latter operates to directly affect the output characteristics of the signal generator **402** using the feedback circuit **440**.

Fig. 7 illustrates an invasive device **500** according to yet another embodiment of the invention for the treatment of internal tissues using ultrasonic waves. The device **500** is constructed generally similar to the above-described examples, but has a flexible tip **504** formed with an insulation coating **502**, which is required to prevent undesirable contact of the tip **504** with non-target tissues.

In order to affect an organ **512**, at a desired treatment point TP_3, the insulated tip **504** should be inserted into the body wall **510** via tissue **514**, in such a manner that the distance between an irradiating phase **515** of the transducer **6** and the treatment point TP_3 will is equal to the frequency resonant distance RD_6. The resonance effect will be best achieved, when an area **517** located slightly deeper than that of the resonant distance RD_6, i.e., deeper than the treatment point TP_3 in the wave propagation direction, has acoustic characteristics different from those of the treatment zone TP_3 itself. Otherwise, the effect will mostly be carried out by strain. In this specific example, the treated area TP_3 is a plucked valve at the outlet of heart **512**.

Those skilled in the art will readily appreciate that various modifications and changes can be applied to the preferred embodiment of the invention as hereinbefore exemplified without departing from its scope defined in and by the appended claims. For example, a treatment zone, where the resonance condition is to be created, may be located inside an object through which this zone is treated, or outside the object. The object may be entirely located inside tissue or may partly project therefrom. Consequently, the acoustic waveguide element of the resonator may be brought is direct contact with the projecting part of the object, or not. The object itself may and may not be part of the resonator, depending on the predetermined location relative to the object, where the treatment zone is to be created.

CLAIMS:

1. A device for affecting an object of a body, the device comprising a transducer actuated by a power source for generating acoustic waves and a resonator transmitting said acoustic waves and producing resonating waves that cause a desired effect within a treatment zone located substantially at a predetermined location relative to the object.

2. The device according to Claim 1, wherein said desired effect is a resonance condition, resonating waves causing maximal vibrations of the treatment zone.

3. The device according to Claim 1, wherein said desired effect is a strain condition, the resonating waves thereby causing maximal strain of the treatment zone.

4. The device according to Claim 1, wherein said resonator comprises an acoustic waveguide element which is by its one end coupled to the transducer and by its opposite, distal end extends towards said predetermined location, the parameters of the resonator being adjusted so as to create the resonance condition in said treatment zone.

5. The device according to Claim 1, wherein said acoustic waveguide element comprises a horn having desired acoustic-wave transmission properties.

6. The device according to Claim 5, wherein said horn is hollow filled with a medium having desired acoustic-wave transmission properties.

7. The device according to Claim 5, wherein the resonator also comprises a tip-like element, which is by its end coupled to a distal end of the horn, and by its opposite end extends towards the predetermined location.

8. The device according to Claim 4, wherein said distal end of the acoustic waveguide element is insertable into the object.

9. The device according to Claim 8, wherein the acoustic waveguide element comprises a flexible waveguide element insertable into the object by its distal end.

10. The device according to Claim 1, wherein said object is part of the resonator being coupled to the distal end of the acoustic waveguide element.

11. The device according to Claim 1, wherein said object has an end-portion thereof projecting outside the body.

12. The device according to Claim 1, wherein said object is entirely located inside the body.

13. The device according to Claim 10, wherein the distal end of the acoustic waveguide element is formed with a beveled edge.

14. The device according to Claim 10, wherein the distal end of the acoustic waveguide element is formed with a sloped edge.

15. The device according to Claim 1, wherein said transducer generates acoustic waves with varying frequencies in accordance to a predetermined frequency pattern.

16. The device according to Claim 15, wherein said predetermined location at which the resonating waves are to be created is a portion of the object located inside the body.

17. The device according to Claim 15, wherein said predetermined location at which the resonating waves are to be created is said end-portion of the object located outside the body.

18. The device according to Claim 11, wherein said object to be affected is an individual's hair.

19. The device according to Claim 11, wherein said object to be affected is a patient's tooth.

20. The device according to Claim 18, wherein said predetermined location is the hair root, the hair shaft serving as part of the resonator.

21. The device according to Claim 19, wherein said predetermined location is the tooth root, the tooth serving as part of the resonator.

22. The device according to Claim 12, wherein said object to be effected is a patient's bone, said predetermined location where the resonating waves are to be created being located inside the bone, said bone serving as part of the resonator.

23. The device according to Claim 12, wherein said object to be effected is a patient's bone, said predetermined location where the resonating waves are to be created being located outside the bone in the vicinity thereof, said bone serving as part of the resonator.

24. The device according to Claim 12, wherein said object is a patient's heart, said predetermined location where the resonating waves are to be created being the heart valve.

25. A cosmetic method for the removal of hair, comprising the steps of:

(a) generating acoustic waves;

(b) transmitting the acoustic waves through a resonator and moving an acoustic waveguide element of the resonator to scan a hairs containing skin portion with transmitted acoustic waves, wherein said transmitted acoustic waves are resonating waves causing a desired effect within a treatment zone located substantially at a predetermined location relative to the hair.

26. The method according to Claim 25, wherein said scanning comprises the step of varying the frequency of the generated acoustic waves in accordance with a predetermined frequency pattern.

27. The method according to Claim 25, wherein said scanning comprises varying the location of the point of contact of the acoustic waveguide element with the hair along an axis substantially perpendicular to the skin portion.

28. The method according to Claim 25, wherein said predetermined location is located substantially at an end-portion of the hair projecting out of skin.

29. The method according to Claim 25, wherein said predetermined location is located substantially at a root portion of the hair.

30. A method affecting an object of a body, the method comprising the steps of:

(i) generating acoustic waves;

(ii) transmitting the acoustic waves through a resonator and moving an acoustic waveguide element of the resonator to scan a skin portion in the vicinity of said object with transmitted acoustic waves, wherein said

transmitted acoustic waves are resonating waves causing a desired effect within a treatment zone located substantially at a predetermined location relative to said object.

31. The method according to Claim 30, wherein said object is at least one of the following list: hair, tooth, bone, heart, tissue, living creature part.

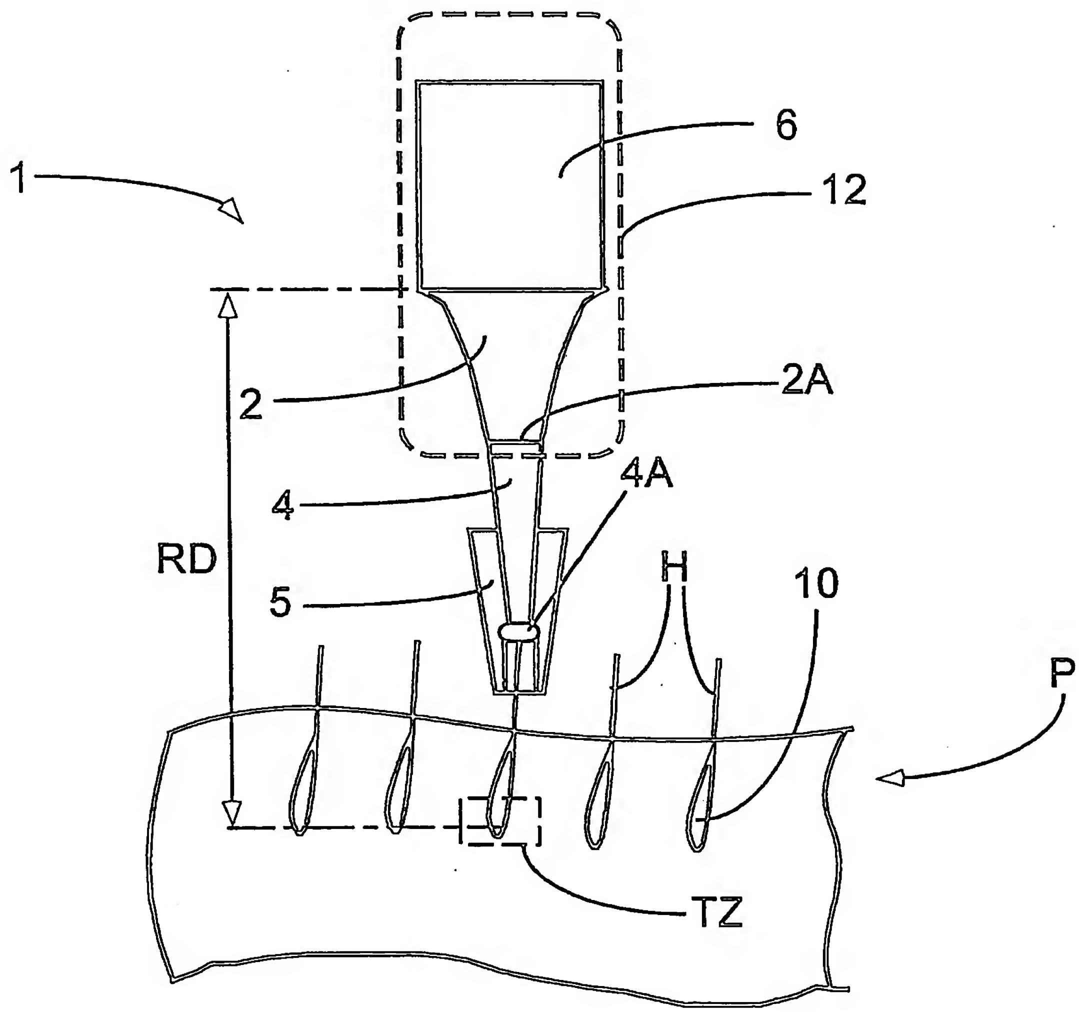

Fig.1

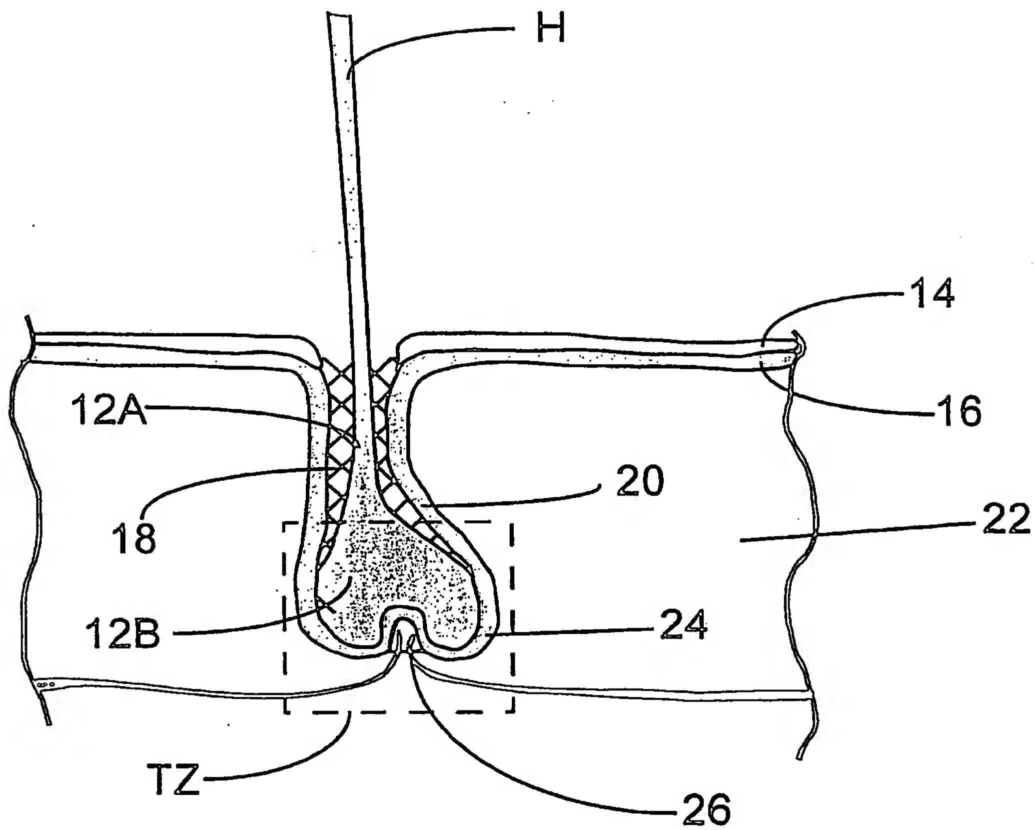

Fig.2

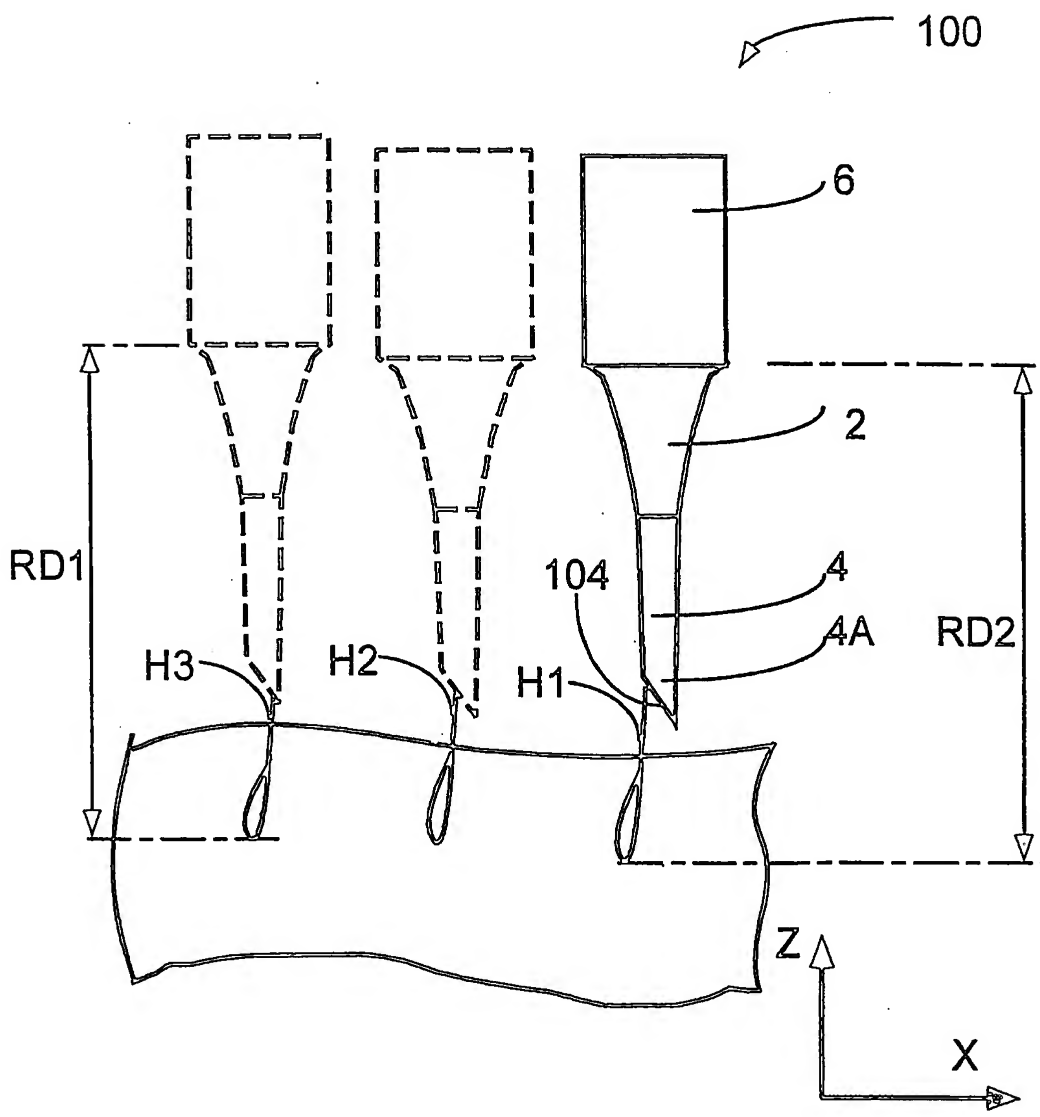

Fig.3

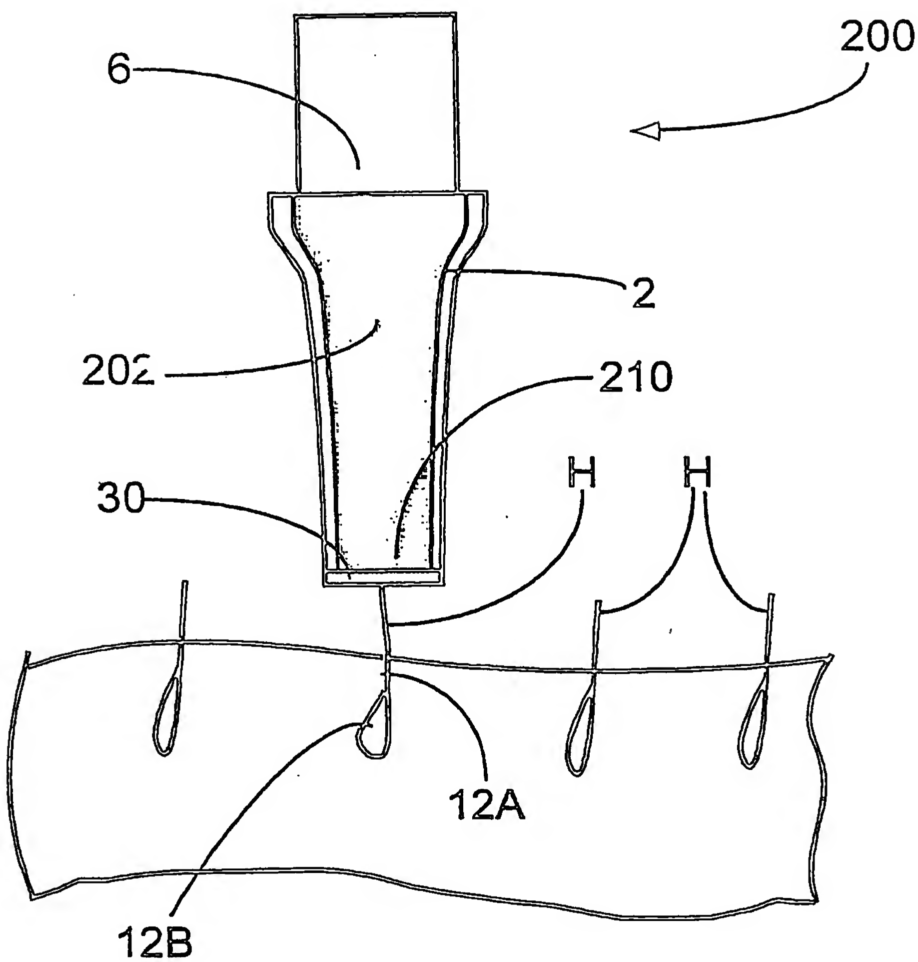

Fig.4

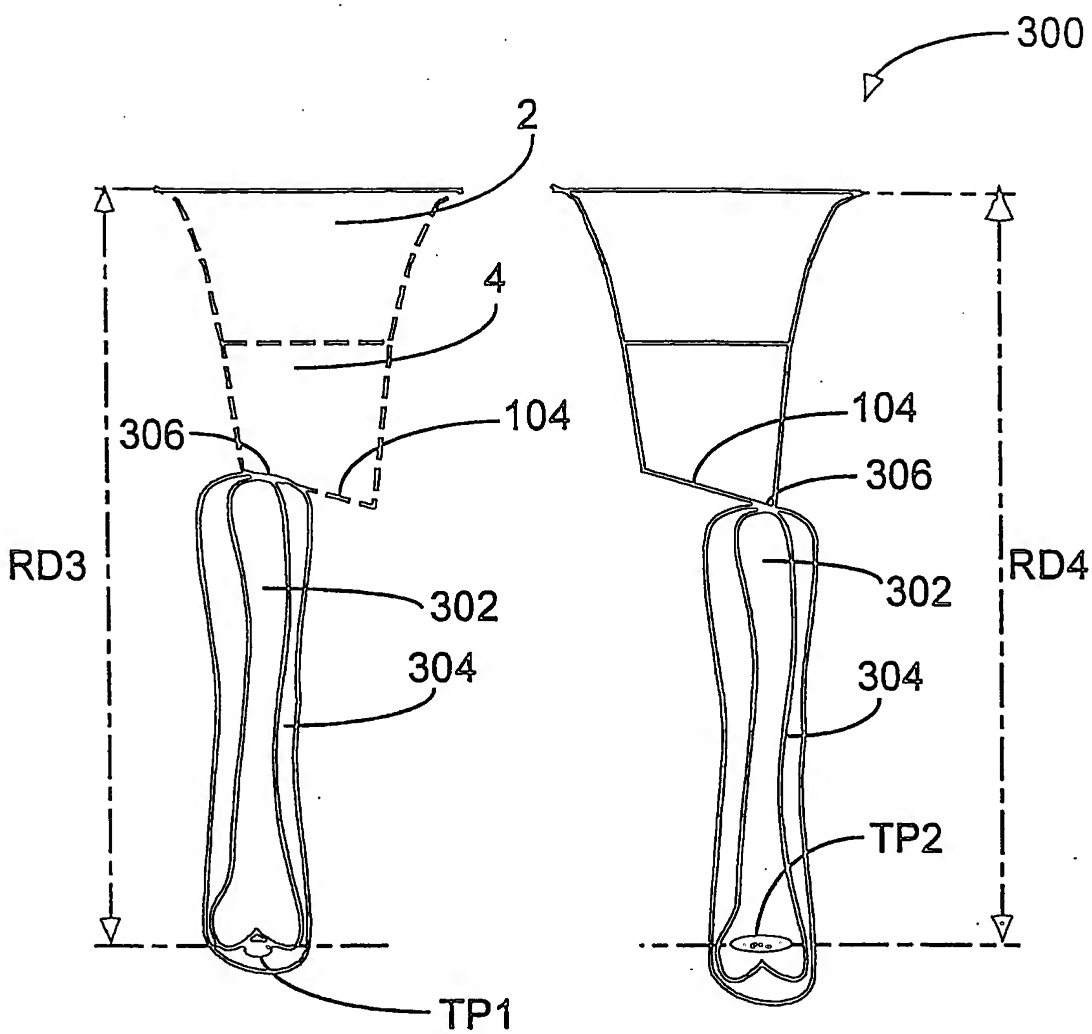

Fig.5A Fig.5B

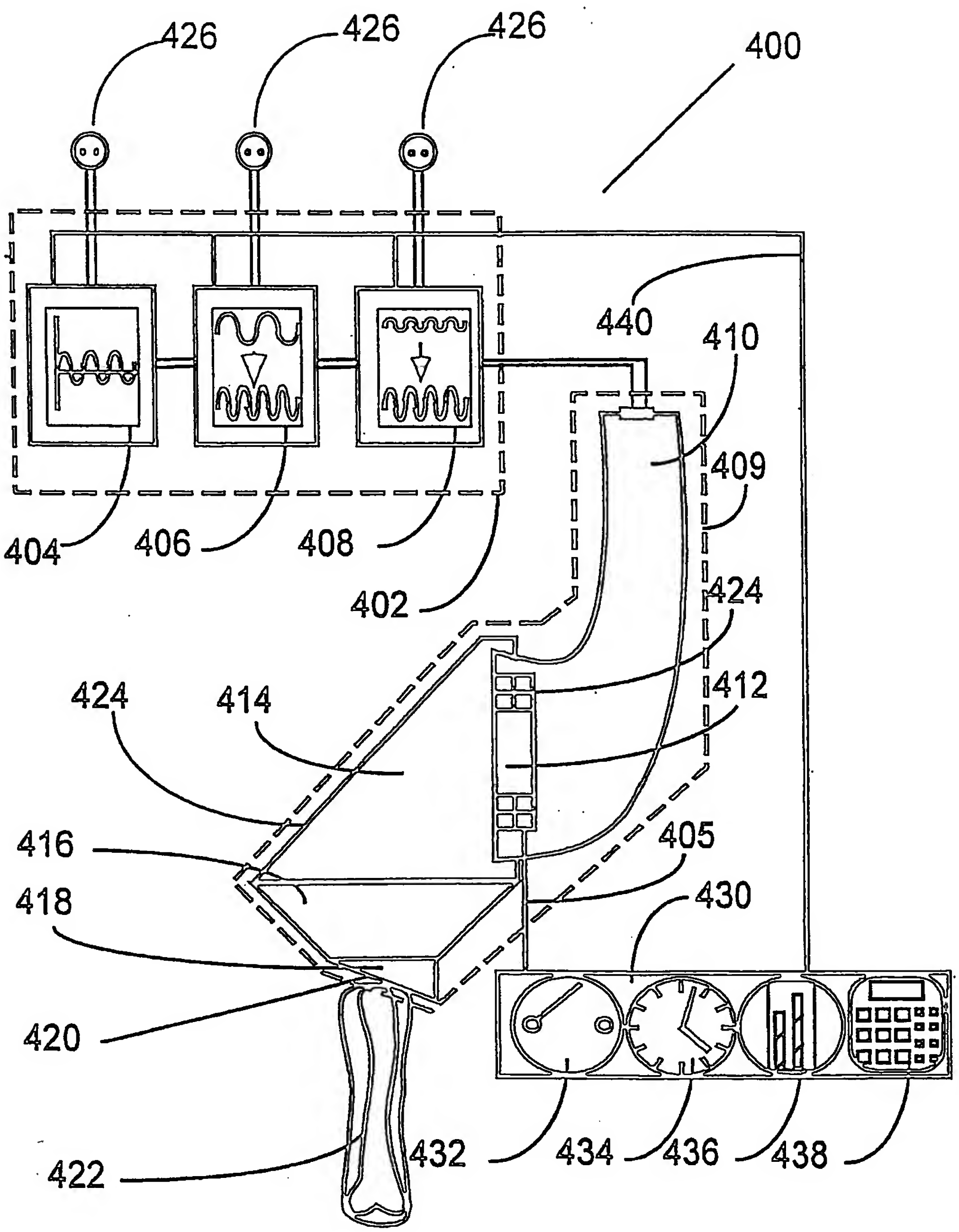
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Fig. 6

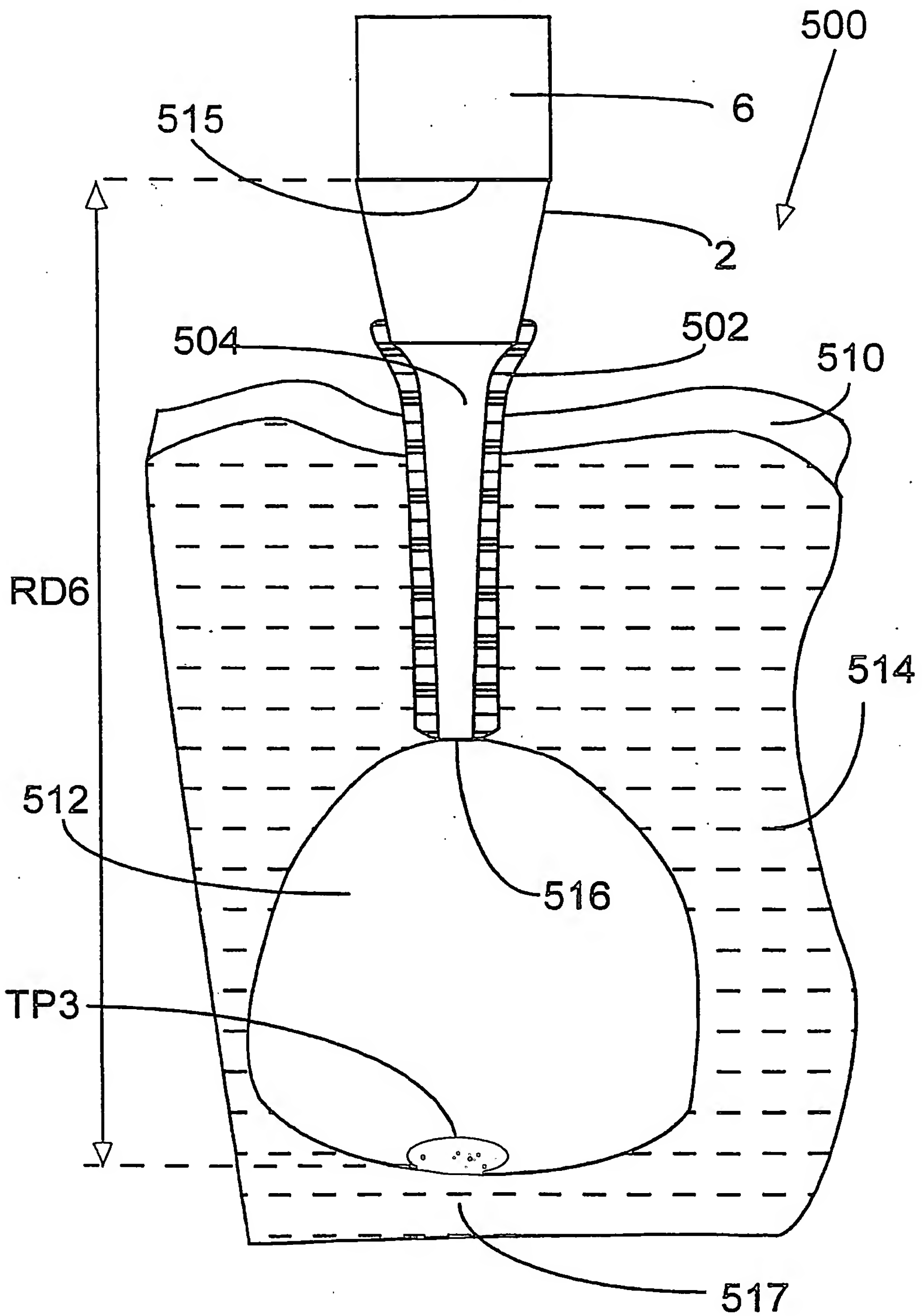

Fig.7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 00/00625

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61N7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61N A61B A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	column 15, line 23 - line 26; figure 1	8,19,21
A		7,10,15, 20,24, 26,27
X	GB 2 277 448 A (THODIYIL PAUL ALBERT) 2 November 1994 (1994-11-02)	1-4,10, 11,15,16
A	page 7, line 20 - line 36; figure 2	22,23
X	US 5 222 937 A (KAGAWA HIROAKI) 29 June 1993 (1993-06-29)	1,5
A	abstract	7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 January 2001	29/01/2001

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 00/00625

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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